Survivability of Accidents Involving Part 121 U.S. Air Carrier Operations, 1983 Through 2000

Safety Report
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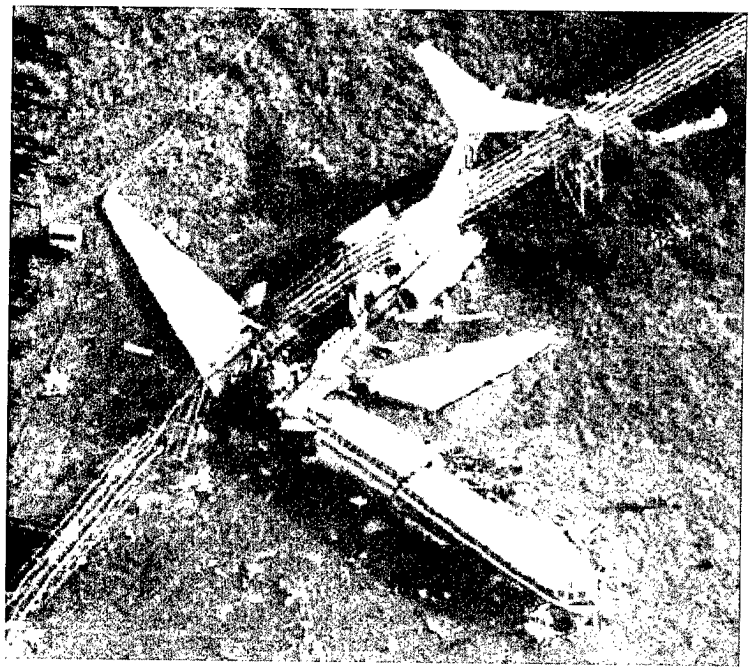

National Transportation Safety Board
Washington, D.C.

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National Transportation Safety Board
490 L'Enfant Plaza, S.W.
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National Transportation Safety Board. ***Survivability of Accidents Involving Part 121 U.S. Air Carrier Operations, 1983 Through 2000.*** **Safety Report NTSB/SR-01/01. Washington, DC: NTSB, 2001.**

Abstract: Despite the growing demands on the U.S. aviation system, the system continues to maintain a high level of safety. There are two ways to prevent fatalities in air travel: by preventing accidents, and by protecting aircraft occupants in the accidents that do occur. A reduction in accident rates provides an indication of the success of accident prevention; examining occupant survivability can indicate the positive results from occupant protection. The importance of examining occupant survivability in aviation accidents is twofold: (1) it can help to dispel a public perception that most air carrier accidents are not survivable, and (2) it can identify things that can be done to increase survivability in the accidents that do occur.

The National Transportation Safety Board frequently receives inquiries from the general public and Government agencies concerning the survivability of airplane accidents. Although the Safety Board's *Annual Review of Aircraft Accident Data for U.S. Air Carrier Operations* summarizes the degree of occupant injury by aircraft damage, the annual publication has not, in the past, analyzed the issue of survivability in detail. Therefore, the purpose of this safety report is to examine aircraft occupant survivability for air carrier operations in the United States. The Safety Board examined only air carrier operations performed under Title 14 *Code of Federal Regulations* Part 121 because the majority of the Board's survival factors investigations are conducted in connection with accidents involving Part 121 carriers. Therefore, more survivability data are available for Part 121 operations than are available for Part 135 and Part 91 (general aviation) operations. This report also examines cause-of-death information for the most serious of the Part 121 accidents; that is, those accidents involving fire, at least one serious injury or fatality, and either substantial aircraft damage or complete destruction.

Contents

Cover: The accident of this McDonnell Douglas MD-82, which occurred on June 1, 1999, involved fire and substantial airplane damage. Of the 145 occupants on board, 134 survived the accident.

Acronyms

CAA	Civil Aviation Authority of the United Kingdom
CAMI	Civil Aeromedical Institute of the FAA
CFR	*Code of Federal Regulations*
ETSC	European Transport Safety Council
FAA	Federal Aviation Administration
NTSB	National Transportation Safety Board

Executive Summary

Passenger enplanements in the United States more than doubled in the 16 years following 1983. According to recent Federal Aviation Administration forecasts, this growth is expected to continue, approaching 1 billion enplanements by the year 2010 (an additional 53-percent increase). Despite the growing demands on the U.S. aviation system, the system continues to maintain its high level of safety. The accident rate for commercial aircraft has remained about the same for the past two decades. If the accident rate continues, however, increased traffic projected over the next 10 years will be accompanied by a commensurate increase in the number of aircraft accidents. To prevent this from occurring, Government agencies are working with industry to reduce the rate of accidents.

There are two ways to prevent fatalities in air travel: by preventing accidents, and by protecting aircraft occupants in the accidents that do occur. A reduction in accident rates provides an indication of the success of accident prevention; examining occupant survivability can indicate the positive results from occupant protection. The importance of examining occupant survivability in aviation accidents is twofold: (1) it can help to dispel a public perception that most air carrier accidents are not survivable, and (2) it can identify things that can be done to increase survivability in the accidents that do occur.

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Introduction

Passenger enplanements in the United States more than doubled in the 16 years following 1983. This growth is expected to continue, approaching 1 billion enplanements by the year 2010 (an additional 53-percent increase).[1] Commensurate with the increase in the number of people traveling will be an increase in the miles that air carriers fly. In 1999, U.S. air carriers flew 6.8 billion miles, a 50-percent increase from 10 years prior. Despite the growing demands on the U.S. aviation system, the system continues to maintain a high level of safety. The accident rate for commercial aircraft has remained about the same for the past two decades. If the accident rate continues, however, increased traffic projected over the next 10 years will be accompanied by a commensurate increase in the number of aircraft accidents.[2] To prevent this from occurring, Government agencies are working with industry to reduce the rate of accidents.

In 2000, there were 54 accidents involving U.S. air carrier flights operating under Title 14 *Code of Federal Regulations* (CFR) Part 121; 92 fatalities occurred aboard the accident aircraft. When the accident rate for 2000 is adjusted for operating hours (0.299 per 100,000 flight hours), it is the same as that for 1999 (0.299) when there were 52 accidents and 11 fatalities aboard accident aircraft, essentially the same for 1998 (0.297) when there were 50 accidents and 0 fatalities aboard accident aircraft, and slightly lower than 1997 (0.309) when there were 49 accidents and 6 fatalities aboard accident aircraft (table 1).

In 1996, Part 121 carriers experienced 37 accidents that resulted in 350 fatalities. Although the 1996 accident rate (0.269 per 100,000 flight hours) was lower than in 2000 (0.299), 1999 (0.299), 1998 (0.297), or 1997 (0.309), the total number of fatalities was substantially greater because of two severe accidents (Trans World Airlines flight 800[3] and ValuJet flight 592[4]) in which 340 occupants were killed.

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[1] U.S. Department of Transportation, Federal Aviation Administration, *FAA Aerospace Forecasts*, FAA-APO-00-1 (Washington, DC: FAA, 2000) X-13.

[2] For example, the Federal Aviation Administration's Safer Skies initiative with industry that seeks to reduce the fatal accident rate by 80 percent by the year 2007.

[3] National Transportation Safety Board, *In-flight Breakup Over the Atlantic Ocean, Trans World Airlines (TWA) Flight 800, Boeing 747-141, N93119, Near East Moriches, New York, July 17, 1996*, Aviation Accident Report NTSB/AAR-00/03 (Washington, DC: NTSB, 2001).

[4] National Transportation Safety Board, *In-flight Fire and Impact With Terrain, ValuJet Airlines Flight 592, DC-9-32, N904VJ, Everglades, Near Miami, Florida, May 11, 1996*, Aviation Accident Report NTSB/AAR-97/06 (Washington, DC: NTSB, 1997).

Table 1. Accidents, fatalities, and rates for U.S. air carriers operating under Title 14 *Code of Federal Regulations* Part 121, scheduled and nonscheduled service (airlines), 1983 through 2000.

Year	Accidents		Fatalities		Flight hours[a]	Miles flown[a]	Departures[a]	Accidents per 100,000 flight hours		Accidents per 1 million miles flown		Accidents per 100,000 departures	
	All	Fatal	Total	Aboard				All	Fatal	All	Fatal	All	Fatal
1983	23	4	15	14	7,298,799	3,069,318,000	5,444,374	0.315	0.055	0.0075	0.0013	0.422	0.073
1984	16	1	4	4	8,165,124	3,428,063,000	5,898,852	0.196	0.012	0.0047	0.0003	0.271	0.017
1985	21	7	526	525	8,709,894	3,631,017,000	6,306,759	0.241	0.080	0.0058	0.0019	0.333	0.111
1986[b]	24	3	8	7	9,976,104	4,017,626,000	7,202,027	0.231	0.020	0.0057	0.0005	0.319	0.028
1987[b]	34	5	232	230	10,645,192	4,360,521,000	7,601,373	0.310	0.038	0.0076	0.0009	0.434	0.053
1988[b]	30	3	285	274	11,140,548	4,503,426,000	7,716,061	0.260	0.018	0.0064	0.0004	0.376	0.026
1989	28	11	278	276	11,274,543	4,605,083,000	7,645,494	0.248	0.098	0.0061	0.0024	0.366	0.144
1990	24	6	39	12	12,150,116	4,947,832,000	8,092,306	0.198	0.049	0.0049	0.0012	0.297	0.074
1991	26	4	62[c]	49	11,780,610	4,824,824,000	7,814,875	0.221	0.034	0.0054	0.0008	0.333	0.051
1992	18	4	33	31	12,359,715	5,039,435,000	7,880,707	0.146	0.032	0.0036	0.0008	0.228	0.051
1993	23	1	1	0	12,706,206	5,249,469,000	8,073,173	0.181	0.008	0.0044	0.0002	0.285	0.012
1994[b]	23	4	239	237	13,124,315	5,478,118,000	8,238,306	0.168	0.030	0.0040	0.0007	0.267	0.049

Table 1. Accidents, fatalities, and rates for U.S. air carriers operating under Title 14 *Code of Federal Regulations* Part 121, scheduled and nonscheduled service (airlines), 1983 through 2000. *(Continued)*

Year	Accidents		Fatalities		Flight hours[a]	Miles flown[a]	Departures[a]	Accidents per 100,000 flight hours		Accidents per 1 million miles flown		Accidents per 100,000 departures	
	All	Fatal	Total	Aboard				All	Fatal	All	Fatal	All	Fatal
1995	36	3	168	162	13,505,257	5,654,069,000	8,457,465	0.267	0.022	0.0064	0.0005	0.426	0.035
1996	37	5	380	350	13,746,112	5,873,108,000	8,228,810	0.269	0.036	0.0063	0.0009	0.450	0.061
1997[d]	49	4	8	6	15,838,109	6,691,693,342	10,313,826	0.309	0.025	0.0073	0.0006	0.475	0.039
1998	50	1	1	0	16,821,641	6,741,690,357	10,985,345	0.297	0.006	0.0074	0.0001	0.455	0.009
1999	52	2	12	11	17,381,999	7,032,971,162	11,092,839	0.299	0.012	0.0074	0.0003	0.469	0.018
2000[e]	54	3	92	92	18,040,000	7,134,600,000	11,587,000	0.299	0.017	0.0076	0.0004	0.466	0.026

[a] Flight hours, miles, and departures are compiled by the Federal Aviation Administration.

[b] "Accidents" and "Fatalities" for this year include a case of suicide/sabotage, but the case is excluded from accident rates for the year. (**1986:** An accident near Athens, Greece, involving an aircraft operated by Trans World Airlines resulted in 4 fatalities, all of which occurred aboard. **1987:** An accident in San Luis Obispo, California, involving an aircraft operated by Pacific Southwest Airlines resulted in 43 fatalities, all of which occurred aboard. **1988**: An accident in Lockerbie, Scotland, involving an aircraft operated by Pan American World Airways resulted in 270 fatalities, 259 of which occurred aboard. **1994:** An accident in Memphis, Tennessee, involving Federal Express resulted in 0 fatalities.)

[c] The 62 total fatalities in 1991 includes 12 persons killed aboard a Skywest commuter aircraft (operating under 14 CFR Part 135) and 22 persons killed aboard the USAir transport category airplane (operating under 14 CFR Part 121) when the two aircraft collided.

[d] Effective March 20, 1997, the data include aircraft with 10 or more passenger seats that formerly conducted scheduled passenger operations under 14 CFR Part 135.

[e] Data for 2000 are preliminary.

Source: Unless indicated otherwise, data are from the aviation accident database of the National Transportation Safety Board.

Fatal accidents such as TWA flight 800, ValuJet flight 592, and EgyptAir flight 990[5] receive extensive media coverage. Nonfatal accidents, however, receive little coverage. As a result, the public may perceive that most air carrier accidents are not survivable. In 1992, for example, the Civil Aviation Authority (CAA) of the United Kingdom found that people rated aircraft accidents as the least survivable type of transportation accident. Further, 32.7 percent of the people the CAA surveyed about the likelihood of accident survival believed that they would be unlikely to survive an aircraft accident.[6]

There are two ways to prevent fatalities in air travel: by preventing accidents, and by protecting aircraft occupants in the accidents that do occur. A reduction in accident rates provides an indication of the success of accident prevention; examining occupant survivability can indicate the positive results from occupant protection. The importance of examining occupant survivability in aviation accidents is twofold: (1) it can help to dispel a public perception that most air carrier accidents are not survivable; and (2) it can identify things that can be done to increase survivability in the accidents that do occur.

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[5] On October 31, 1999, EgyptAir flight 990, a scheduled international flight from New York to Cairo, crashed in the Atlantic Ocean about 60 miles south of Nantucket Island, Massachusetts. All 217 occupants were killed. The accident occurred in international waters, thus Egypt, under Annex 13 to the Convention on International Civil Aviation, had authority to conduct or delegate the investigation. In accordance with the standards of the Convention, Egypt requested that the United States conduct the investigation of the accident; the National Transportation Safety Board, on behalf of the United States, accepted responsibility to conduct the investigation.

[6] P.J. Fennell and H.C. Muir, *Passenger Attitudes Towards Airline Safety Information and Comprehension of Safety Briefings and Cards*, CAA Paper 92015 (London: Civil Aviation Authority, 1992).

[7] In June 1980, the Safety Board produced a similar report for testimony to the House Subcommitte on Oversight and Review of the Public Works and Transportation Committee of the 96th Congress.

Aviation Accident Survivability

Several organizations have attempted to develop general statistics on aviation accident survivability. The European Transport Safety Council (ETSC) examined the survivability of accidents worldwide and estimated that 90 percent of aircraft accidents are survivable (as defined by no passengers are killed) or "technically survivable" (as defined by at least one occupant survives).[8] On the basis of these definitions, the ETSC estimated that of the 1,500 people who die annually in air transport accidents, 600 people who should survive die in survivable accidents. Of these 600, the ETSC further estimated that 330 fatalities result from impact and 270 result from fire-related factors (including smoke) that occurred after impact. However, the ETSC indicated that "these figures are best estimates, since insufficient detailed accident information is available."

Researchers at the Federal Aviation Administration (FAA) examined, in the mid-1990s, a selected set of survivable accidents that occurred from 1970 to 1995 in the United States. Their report was described in the agency's employee newsletter, the *FAA Intercom*.[9] The researchers found that 68 percent of occupants involved in aircraft accidents died as a result of injuries sustained during postcrash fires. This number of fire-related fatalities was substantially higher than the ETSC estimates with respect to the proportion of fatalities from fire. However, not all accidents that occurred during the study period were included in the FAA analysis.

Congress charges the National Transportation Safety Board with investigating every civil aviation accident in the United States. An accident is defined as an "occurrence associated with the operation of an aircraft . . . in which any person suffers death or serious injury, or in which the aircraft receives substantial damage" (49 CFR Part 830.2). The Safety Board also is responsible for maintaining a database on civil aviation accidents. The database contains a record for, among others, every accident involving Part 121 air carriers. At the end of each calendar year, the Safety Board releases the data and analysis of the accident rates for that year (see table 1).

For this report, the Safety Board conducted a review of its aviation accident/incident database to examine several aspects of occupant survival in aircraft accidents that occurred during Part 121 operations. The review examined each Part 121 accident from 1983 (the first year of the Board's current aviation accident database) through 2000 (the last full year in the database). The numbers of accidents, fatalities, and survivors for these years are given in table 2.

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[8] European Transport Safety Council, *Increasing the Survival Rate in Aircraft Accidents: Impact Protection, Fire Survivability, and Evacuation* (Brussels, Belgium: ETSC, 1996).

[9] "CAMI [Civil Aeromedical Institute] Helps Flyers Survive Aircraft Accidents," *Headquarters Intercom* March 17 (1998): 1–2 (Washington, DC: Federal Aviation Administration). The FAA's results were also reported by the following publication: *Surviving the Crash: The Need to Improve Lifesaving Measures at Our Nation's Airports* (Washington, DC: Coalition for Airport and Airplane Passenger Safety [CAAPS], 1999). The CAAPS report incorrectly attributes the research to the National Transportation Safety Board.

Table 2. Fatality and survivor data from National Transportation Safety Board investigation records for all accidents involving U.S. air carrier flights (cargo and passenger) operating under Title 14 *Code of Federal Regulations* Part 121, 1983 through 2000.

	Number of accidents		Number of occupants		
Year	Total	Fatal	Total	Survivors	Fatalities
1983	23	4	1,603	1,589	14
1984	16	1	1,530	1,526	4
1985	21	7	1,524	999	525
1986	24	3	2,599	2,592	7
1987	34	5	3,204	2,974	230
1988	30	3	3,516	3,242	274
1989	28	11	2,679	2,403	276
1990	24	6	2,264	2,252	12
1991	26	4	1,811	1,762	49
1992	18	4	1,904	1,873	31
1993	23	1	2,246	2,246	0
1994	23	4	2,305	2,068	237
1995	36	3	4,083	3,921	162
1996	37	5	3,902	3,552	350
1997	49	4	5,270	5,264	6
1998	50	1	4,550	4,550	0
1999	52	2	4,297	4,286	11
2000	54	3	4,200	4,108	92
Total	**568**	**71**	**53,487**	**51,207**	**2,280**
Percent[a]		**12.5**		**95.7**	**4.3**

[a] Percentages have been rounded to the nearest tenth.

Source: Aviation accident database of the National Transportation Safety Board.

There were 568 accidents involving Part 121 air carriers from 1983 through 2000; 71 of the 568 accidents (12.5 percent) resulted in at least one occupant fatality. As figure 1 shows, 51,207 occupants survived whereas 2,280 occupants died in these 568 accidents. Overall for the review period, 95.7 percent of the occupants involved in a Part 121 air carrier accident survived the accident.

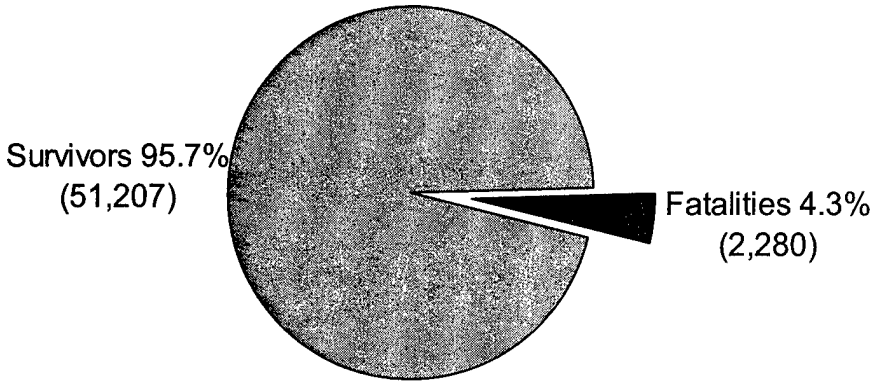

Figure 1. Fatality and survivor data for all accidents involving U.S. air carrier flights (cargo and passenger) operating under Title 14 *Code of Federal Regulations* Part 121, 1983 through 2000.

The number of aircraft occupant survivors and fatalities varied widely over the 18-year period (figure 2). The percentage of fatalities was highest for 1985: 34 percent of the occupants in accidents involving Part 121 operations were fatally injured. Each of the seven fatal accidents in 1985 resulted in fatal injuries to the majority of occupants. The next highest percentage (10 percent) of occupant fatalities occurred in 1989, in which each of two accidents resulted in over 100 fatalities, and in 1994, in which three accidents resulted in fatal injuries to most of the occupants.

Because a public perception is that aviation accidents are not survivable, the Safety Board also examined the proportion of occupants who survived in each accident for the period 1983 through 2000. Contrary to public perception, the most likely outcome of an accident is that most people survive. In 528 of the 568 accidents (93.0 percent), more than 80 percent of the occupants survived (figure 3). Accidents that result in complete or near complete loss of life, such as TWA flight 800, account for a small percentage of all accidents. Only 34 of the 568 accidents (5.9 percent) resulted in fewer than 20 percent of the occupants surviving.

Because in the majority of Part 121 accidents the occupants' survival was never threatened, the Safety Board focused on the survivability in serious accidents. For the purpose of examining this subset of all Part 121 accidents, the Board defined a serious accident as one that involved fire (precrash or postcrash), at least one serious injury or

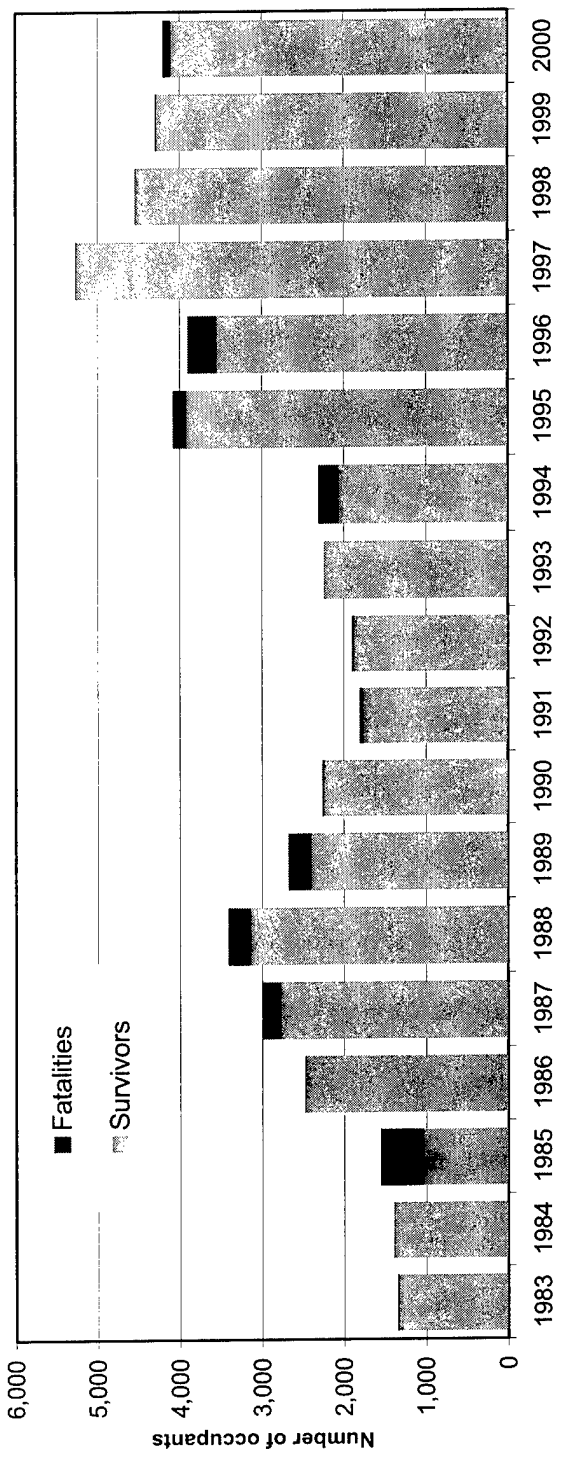

Figure 2. Number of survivors and fatalities for all accidents involving U.S. carrier flights (cargo and passenger) operating under Title 14 *Code of Federal Regulations* Part 121, 1983 through 2000. (Source: Aviation accident database of the National Transportation Safety Board.)

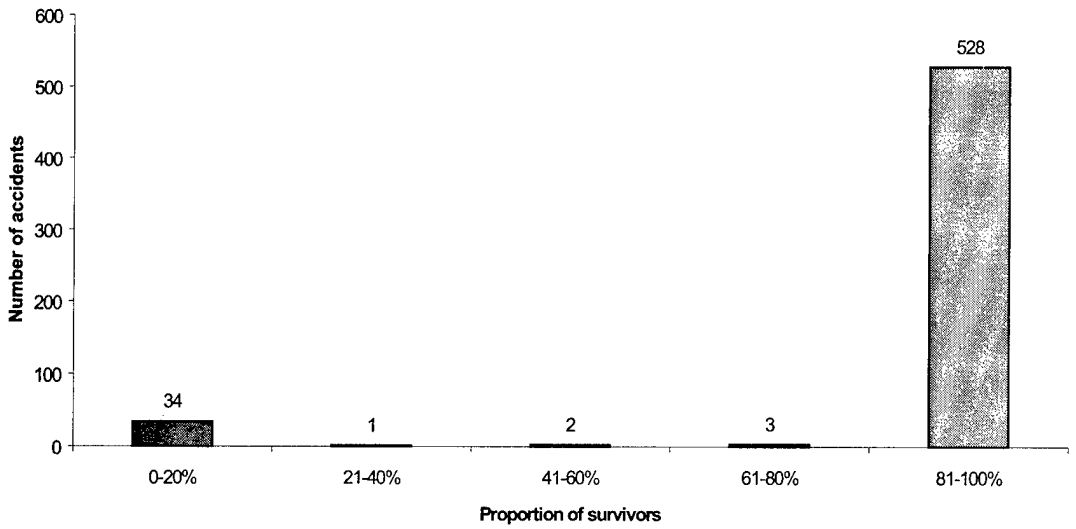

Figure 3. Number of accidents with proportions of survivors for all accidents involving U.S. air carrier flights (cargo and passenger) operating under Title 14 *Code of Federal Regulations* Part 121, 1983 through 2000. (Source: Aviation accident database of the National Transportation Safety Board.)

fatality, and either substantial aircraft damage[10] or complete destruction. The Board reviewed its accident database, accident reports, public dockets, and its investigation files for information pertinent to determining the percent of occupants surviving these serious accidents.[11] The cause of death, obtained from autopsy reports, represents the opinion of a pathologist or coroner authorized by the State or territory to make that determination.

From 1983 through 2000, the Safety Board investigated 26 accidents involving fire, serious injury, and either substantial aircraft damage or complete destruction (table 3). There were 2,739 occupants involved in these serious accidents; 1,524 (55.6 percent) of the occupants survived the accident, 716 (26.1 percent) of the occupants died from impact, 340 (12.4 percent) died from unknown causes,[12] 131 (4.8 percent) died from fire/smoke, and 28 (1.0 percent) died from other causes.[13] The lowest survivability rates occurred in 1985, when 11.3 percent of the occupants (30 of 265) in three accidents survived, and in 1994, when 7.8 percent of the occupants (20 of 257) in three accidents

[10] Substantial damage is defined in 49 CFR 830.2 as damage or failure which adversely affects the structural strength, performance, or flight characteristics of the aircraft, and would normally require major repair or replacement of the affected equipment.

[11] The Board's analysis of occupant survivability excluded accidents that had not been investigated by the Safety Board. Part 121 fatal accidents not investigated by the Safety Board but documented in the Safety Board's database include the December 20, 1995, crash of an American Airlines Boeing 757 in Cali, Columbia, and the December 12, 1985, crash of an Arrow Airways DC-8 in Gander, Newfoundland.

[12] Autopsy reports did not specify cause of death for the occupants in the 1996 accidents involving TWA flight 800 and ValuJet flight 592.

[13] Fatalities in the "Other" category were caused either by drowning, mechanical asphyxia, or trauma as a result of intrusion by engine or propeller parts.

Table 3. Fatality and survivor data from National Transportation Safety Board investigation records for all Part 121 U.S. passenger flight accidents involving fire, serious injury, and either substantial airplane damage or complete destruction, 1983 through 2000.

Year[a]	Number of[b]—			Number of fatalities by cause[c]			
	Accidents	Occupants	Survivors	Impact	Fire	Other[d]	Unknown[e]
1983	2	175	174	0	0	1	0
1984	1	39	39	0	0	0	0
1985	3	265	30	191	44	0	0
1986	1	23	23	0	0	0	0
1987	2	237	55	173	0	9	0
1988	2	148	134	0	14	0	0
1989	1	296	185	76	35	0	0
1990	1	44	36	3	5	0	0
1991	3	216	169	26	21	0	0
1992	2	343	316	9	2	16	0
1993	0	0	0	0	0	0	0
1994	3	257	20	232	5	0	0
1995	1	62	62	0	0	0	0
1996	3	489	147	0	0	2	340
1997	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0
1999	1	145	134	6	5	0	0
2000	0	0	0	0	0	0	0
Total	**26**	**2,739**	**1,524**	**716**	**131**	**28**	**340**
Percent[f]			**55.6**	**26.1**	**4.8**	**1.0**	**12.4**

[a] Table 4 provides these data by individual accident in the 1983 through 1999 period.

[b] The number of accidents, occupants, and survivors was determined from information in the aviation accident database of the National Transportation Safety Board.

[c] The number of fatalities by cause was obtained from autopsy reports. The cause of death was determined by a pathologist or coroner authorized by the State or territory to make that determination.

[d] Fatalities in the "Other" category were reported by a pathologist or coroner to have been caused either by drowning, mechanical asphyxia, or trauma as a result of intrusion by engine or propeller parts.

[e] "Unknown cause" includes the fatalities for whom a determination as to cause of death was not reported by a pathologist or coroner with sufficient specificity to classify the fatalities as impact-, fire-, or "other cause"-related.

[f] Percentages have been rounded to the nearest tenth.

survived (figure 4). In 1984, 1986, 1995, and 2000, there were no on-board fatalities; thus the survivability rate was 100 percent.

The Safety Board also examined how many occupants survived for each of the serious accidents. The most likely outcome for these serious accidents is that most people survive the accident. In 12 of the 26 serious accidents (46.2 percent), more than 80 percent of the occupants survived (figure 5). In 9 of the 26 serious accidents (35 percent), fewer than 20 percent of the occupants survived.

An important distinction between deaths from impact and deaths from fire is that impact deaths typically occur as a result of aircraft impact forces whereas fire deaths typically occur after impact. In the serious accidents, there were nearly five times more impact fatalities than fire-related fatalities. The high proportion of impact-to-fire fatalities is the result of the inclusion of a number of unsurvivable accidents in the subset. For an accident to be deemed survivable, the forces transmitted to occupants through their seat and restraint system cannot exceed the limits of human tolerance to abrupt accelerations, and the structure in the occupants' immediate environment must remain substantially intact to the extent that a livable volume is provided for the occupants throughout the crash. Using this definition of a survivable accident, the Safety Board examined accident reports and determined that 7 of the 26 serious accidents were not survivable because of the impact forces (see the shaded rows in table 4).

Nineteen of the 26 serious accidents involving Part 121 air carriers were at least partially survivable as indicated in accident reports; 1,523 (76.6 percent) of the 1,988 occupants in these accidents survived, 306 (15.4 percent) of the occupants died from impact, 131 (6.6 percent) died from fire, and 28 (1.4 percent) died from other causes (table 5). In the survivable serious accidents, over twice as many occupants died as a result of impact forces than as a result of fire. Figure 6 shows the cause-of-death data by year for the survivable serious accidents.

As is the case with all Part 121 accidents, the most likely outcome for the serious survivable accidents is that most occupants survive. In 12 of the 19 serious accidents that were survivable (63.2 percent), more than 80 percent of the occupants survived (figure 7). In 2 of the 19 serious accidents that were survivable (10.5 percent), fewer than 20 percent of the occupants survived.

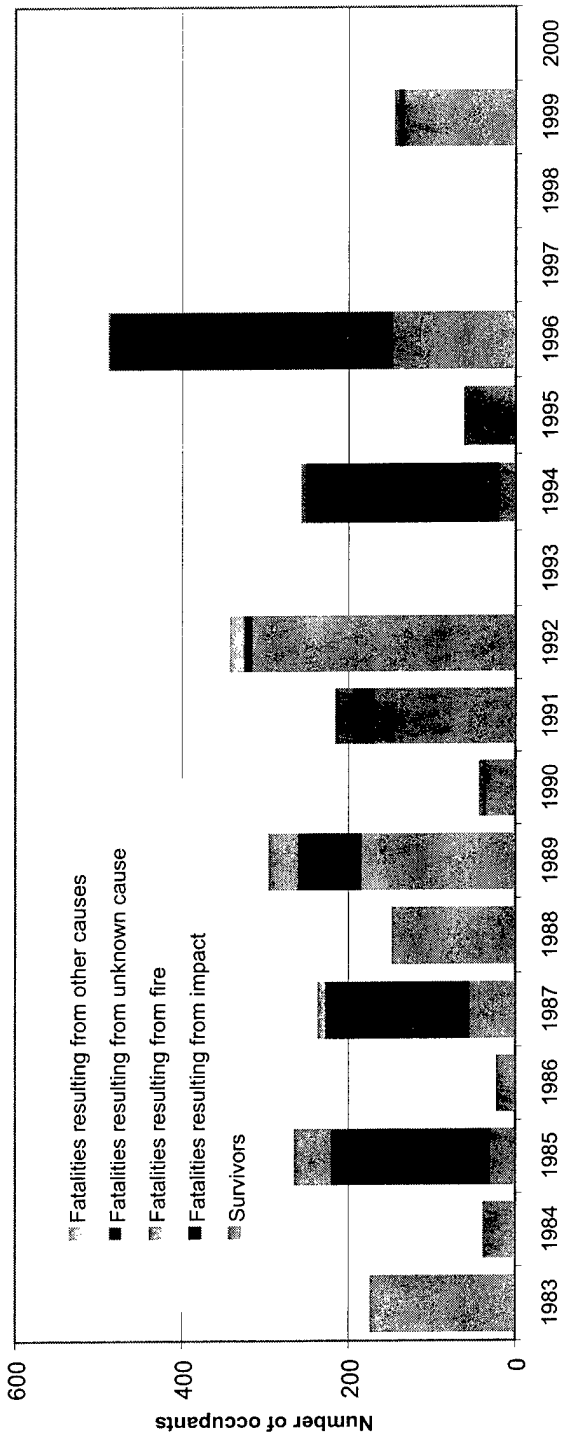

Figure 4. Number of survivors and fatalities for all Part 121 passenger flight accidents involving fire, serious injury, and either substantial airplane damage or complete destruction, 1983 through 2000. "Other cause" includes drowning, mechanical asphyxia, or trauma as a result of intrusion by engine or propeller parts. "Unknown cause" includes the fatalities for whom a determination as to cause of death was not reported by a pathologist or coroner with sufficient specificity to classify the fatalities as impact-, fire-, or "other cause"-related. (Source: National Transportation Safety Board factual reports, which contain pertinent information obtained from autopsy reports.)

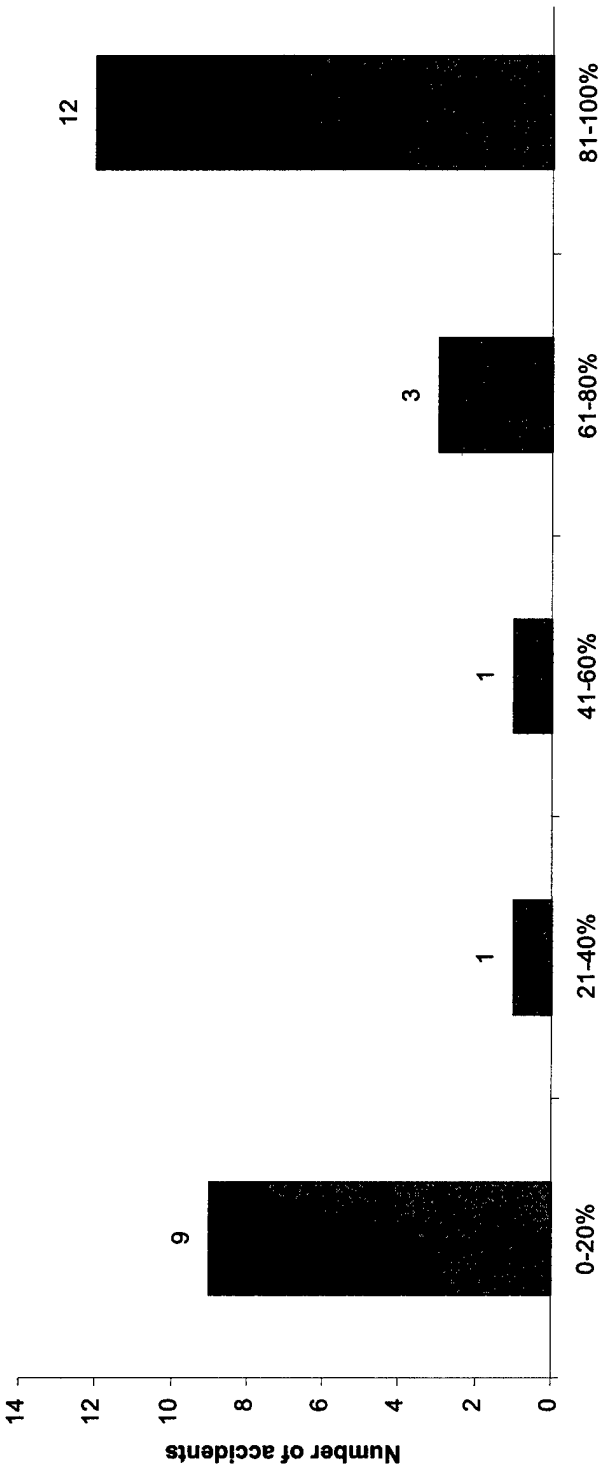

Figure 5. Number of accidents with proportions of survivors for U.S. passenger flights operating under Title 14 *Code of Federal Regulations* Part 121 that involved fire, serious injury, and either substantial aircraft damage or complete destruction, 1983 through 2000. (Source: Aviation accident database of the National Transportation Safety Board.)

Table 4. Fatality and survivor data, by individual accident, from National Transportation Safety Board investigation records for all Part 121 U.S. passenger flight accidents involving fire, serious injury, and either substantial airplane damage or complete destruction, 1983 through 2000.

Date of accident	Location of accident	Airplane type	Number of[a]—			Number of fatalities by cause[b]			
			Occupants	Survivors	Fatalities	Impact	Fire	Other[c]	Unknown[d]
01/09/83	Brainerd, Minnesota	Convair 580-11-A	33	32	1	0	0	1	0
06/11/83	Chicago, Illinois	Boeing 727-222A	142	142	0	0	0	0	0
12/16/84	Jasper, Alabama	Convair 440	39	39	0	0	0	0	0
01/21/85	Reno, Nevada	Lockheed 188C	71	1	70	26	44	0	0
08/02/85	Dallas/Fort Worth, Texas	Lockheed L-1011-385-1	163	29	134	134	0	0	0
09/06/85	Milwaukee, Wisconsin	McDonnell Douglas DC-9-14	31	0	31	31	0	0	0
11/06/86	Tampa, Florida	Boeing 727-235	23	23	0	0	0	0	0
08/16/87	Romulus, Michigan	McDonnell Douglas DC-9-82	155	1	154	154	0	0	0
11/15/87	Denver, Colorado	McDonnell Douglas DC-9-14	82	54	28	19	0	9	0
04/15/88	Seattle, Washington	de Havilland DHC Dash 8	40	40	0	0	0	0	0
08/31/88	Dallas/Fort Worth, Texas	Boeing 727-232	108	94	14	0	14	0	0
07/19/89	Sioux City, Iowa	McDonnell Douglas DC-10-10	296	185	111	76	35	0	0
12/03/90	Romulus, Michigan	McDonnell Douglas DC-9-14	44	36	8	3	5	0	0
02/01/91	Los Angeles, California	Boeing 737-300	89	67	22	1	21	0	0
03/03/91	Colorado Springs, Colorado	Boeing 737-291	25	0	25	25	0	0	0
05/05/91	Atlanta, Georgia	McDonnell Douglas MD-88	102	102	0	0	0	0	0
03/22/92	LaGuardia Airport, Flushing, New York	Fokker 28-4000	51	24	27	9	2	16	0
07/30/92	John F. Kennedy International Airport, Jamaica, New York	Lockheed L-1011-385-1	292	292	0	0	0	0	0
07/02/94	Charlotte, North Carolina	McDonnell Douglas DC-9-31	57	20	37	32	5	0	0
09/08/94	Aliquippa, Pennsylvania	Boeing 737-300	132	0	132	132	0	0	0
10/31/94	Roselawn, Indiana	Avions de Transport Regional (ATR) 72-212	68	0	68	68	0	0	0
06/08/95	Atlanta, Georgia	McDonnell Douglas DC-9-32	62	62	0	0	0	0	0

Table 4. Fatality and survivor data, by individual accident, from National Transportation Safety Board investigation records for all Part 121 U.S. passenger flight accidents involving fire, serious injury, and either substantial airplane damage or complete destruction, 1983 through 2000. (*Continued)*

Date of accident	Location of accident	Airplane type	Number of[a]—			Number of fatalities by cause[b]			
			Occupants	Survivors	Fatalities	Impact	Fire	Other[c]	Unknown[d]
05/11/96	Everglades, Miami, Florida	McDonnell Douglas DC-9-32	110	0	110	0	0	0	110
07/06/96	Pensacola, Florida	McDonnell Douglas MD-88	149	147	2	0	0	2	0
07/17/96	E. Moriches, New York	Boeing 747-131	230	0	230	0	0	0	230
06/01/99	Little Rock, Arkansas	McDonnell Douglas MD-82	145	134	11	6	5	0	0
Total			**2,739**	**1,524**	**1,147**	**716**	**131**	**28**	**340**

An unshaded row (n = 19) indicates that the accident was survivable. A shaded row (n= 7) indicates that the accident was not survivable.

[a] The number of occupants, survivors, and fatalities was determined from information in the aviation accident database of the National Transportation Safety Board.

[b] The number of fatalities by cause was obtained from autopsy reports. The cause of death was determined by a pathologist or coroner authorized by the State or territory to make that determination.

[c] Fatalities in the "Other" category were reported by a pathologist or coroner to have been caused either by drowning, mechanical asphyxia, or trauma as a result of intrusion by engine or propeller parts.

[d] "Unknown cause" includes the fatalities for whom a determination as to cause of death was not reported by a pathologist or coroner with sufficient specificity to classify the fatalities as impact-, fire-, or "other cause"-related.

Table 5. Fatality and survivor data from National Transportation Safety Board investigation records for all survivable Part 121 U.S. passenger flight accidents involving fire, serious injury, and either substantial airplane damage or complete destruction, 1983 through 2000.

Year	Number of[a]—			Number of fatalities by cause[b]			
	Accidents	Occupants	Survivors	Impact	Fire	Other[c]	Unknown[d]
1983	2	175	174	0	0	1	0
1984	1	39	39	0	0	0	0
1985	2	234	30	160	44	0	0
1986	1	23	23	0	0	0	0
1987	1	82	54	19	0	0	9
1988	2	148	134	0	14	0	0
1989	1	296	185	76	35	0	0
1990	1	44	36	3	5	0	0
1991	2	191	169	1	21	0	0
1992	2	343	316	9	2	16	0
1993	0	0	0	0	0	0	0
1994	1	57	20	32	5	0	0
1995	1	62	62	0	0	0	0
1996	1	149	147	0	0	2	0
1997	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0
1999	1	145	134	6	5	0	0
2000	0	0	0	0	0	0	0
Total	**19**	**1,988**	**1,523**	**306**	**131**	**28**	**0**
Percent[e]			**76.6**	**15.4**	**6.6**	**1.4**	**0**

[a] The number of accidents, occupants, and survivors was determined from information in the aviation accident database of the National Transportation Safety Board.

[b] The number of fatalities by cause was obtained from autopsy reports. The cause of death was determined by a pathologist or coroner authorized by the State or territory to make that determination.

[c] Fatalities in the "Other" category were reported by a pathologist or coroner to have been caused either by drowning, mechanical asphyxia, or trauma as a result of intrusion by engine or propeller parts.

[d] "Unknown cause" includes the fatalities for whom a determination as to cause of death was not reported by a pathologist or coroner with sufficient specificity to classify the fatalities as impact-, fire-, or "other cause"-related.

[e] Percentages have been rounded to the nearest tenth.

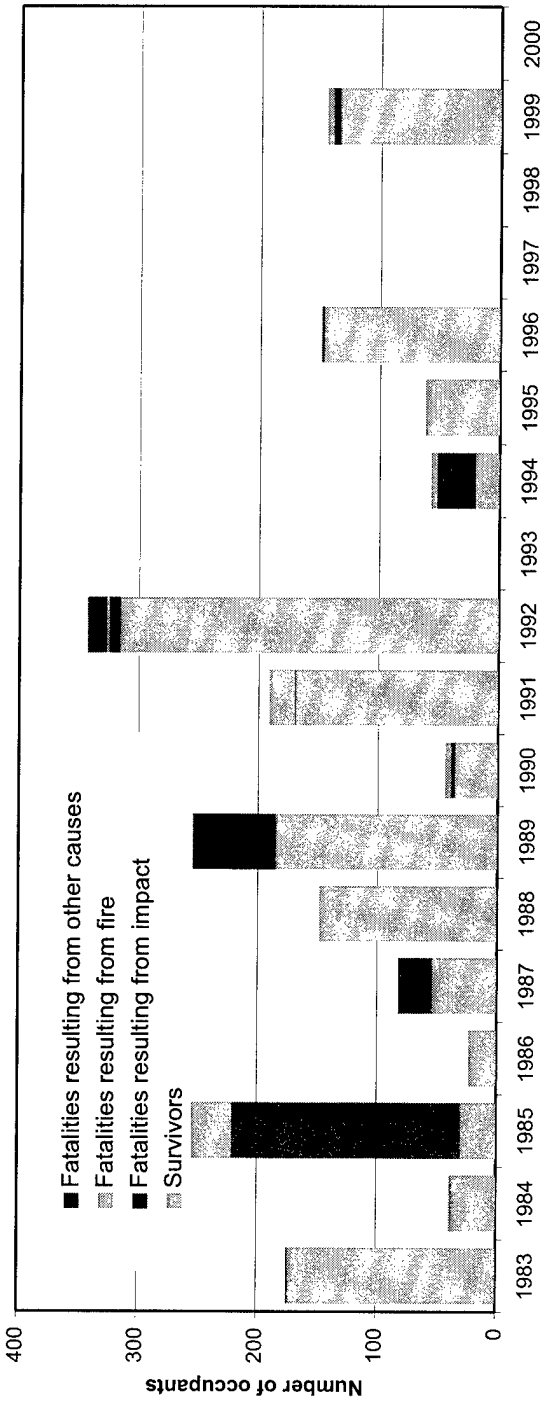

Figure 6. Number of survivors and fatalities for the survivable Part 121 passenger flight accidents involving fire, serious injury, and either substantial airplane damage or complete destruction, 1983 through 2000. "Other cause" includes drowning, mechanical aspyxia, or trauma as a result of intrusion by engine or propeller parts. (Source: National Transportation Safety Board factual reports, which contain pertinent information obtained from autopsy reports.)

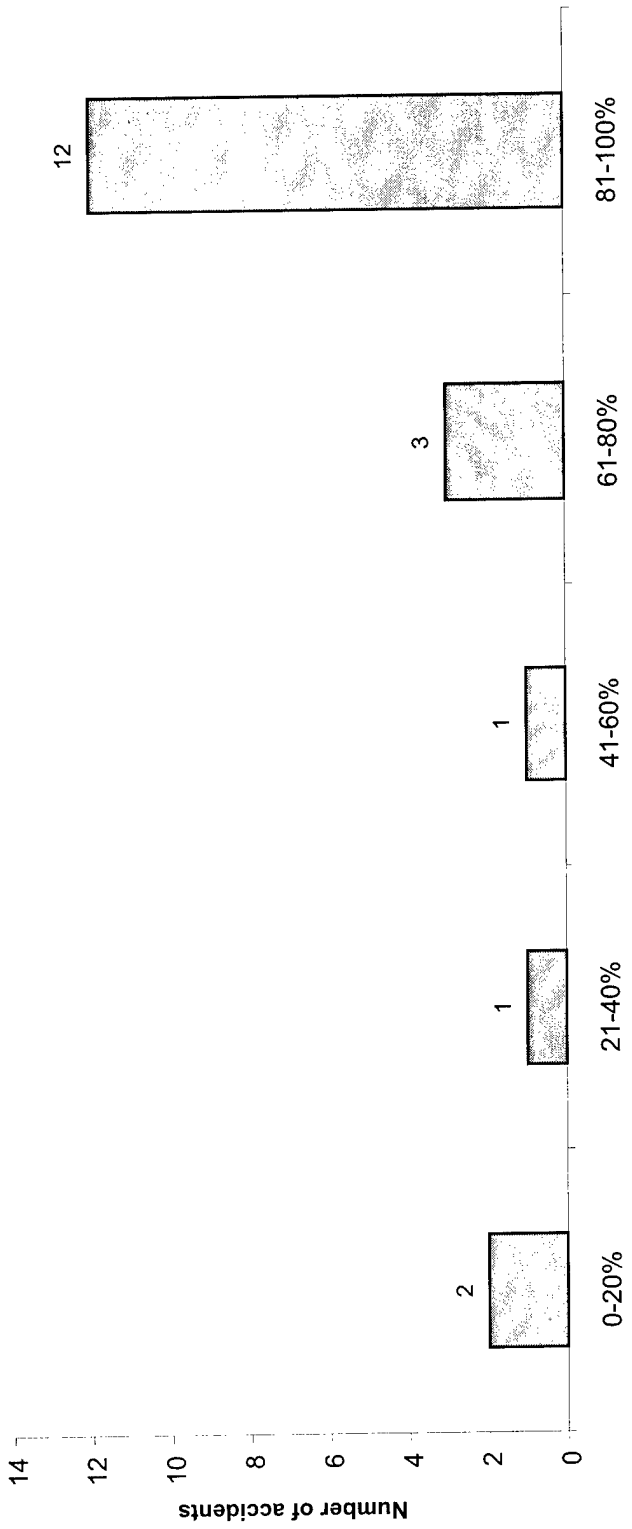

Figure 7. Number of accidents with proportions of survivors for survivable U.S. passenger flights operating under Title 14 *Code of Federal Regulations* Part 121 that involved fire, serious injury, and either substantial aircraft damage or complete destruction, 1983 through 2000. (Source: Aviation accident database of the National Transportation Safety Board and NTSB factual reports, which contain pertinent information obtained from autopsy reports.)

Discussion

Nearly 96 percent of the occupants involved in a Part 121 aviation accident over the past 18 years survived the accident, and in over 46 percent of the most serious of these accidents (accidents involving fire, serious injury, and either substantial aircraft damage or complete destruction), more than 80 percent of the occupants survived. Although catastrophic accidents such as TWA flight 800 result in fatalities to all occupants, such accidents are the exception. The large number of people who survive even the most serious accidents emphasizes the importance of work aimed at ensuring that crash survivors can safely remove themselves from the accident aircraft.

Even in the 19 survivable Part 121 accidents involving fire, occupants were much more likely to die from impact forces than from the effects of fire. These results indicate lower fire-related fatalities than both the ETSC estimates and the FAA research. The difference between the ETSC estimates and the Safety Board's findings may reflect differences in the aviation system in the United States compared to worldwide aviation systems examined for the ETSC estimates. Further, these differences could be the result of differences in the criteria for selecting accidents by which to examine survivability data.

Surviving an accident is the result of many factors. The large number of survivors reflects the efforts of industry and government to ensure passenger safety. Cabin structural integrity, seat belts, seat design, child restraint systems, and brace positions can all increase a person's likelihood of surviving an impact. Fire retardancy, exit design, aircraft configuration, and evacuation procedures can assist persons to escape an airplane after an accident. Over the last decade, air travelers have been provided improvements in many of these areas.

Safety Board recommendations have been the impetus for many of these improvements in occupant protection, including fire detection and suppression systems in lavatories and cargo compartments, modifications in cargo compartments to delay fires from spreading, and fire blocking of cabin and seat materials that also prevent fires from spreading.[14] The Safety Board also recommended floor level escape lighting systems and heat resistant slides to improve occupant escape paths, and recommended improvements for the crashworthiness of passenger seats.

In addition to aircraft design, passenger education plays a crucial role in increasing occupant survival. The FAA requires that passengers receive a preflight briefing and safety card regarding aircraft safety systems. However, many airplane occupants do not pay attention to the preflight briefing, and more than two-thirds never examine the safety

[14] National Transportation Safety Board, *We Are All Safer* (Washington, DC: NTSB, 1998).

briefing card.[15] The FAA emphasizes the importance of these safety briefings directly to the public through documents such as "Fly Smart: An Air Traveler's Guide."[16]

One reason passengers do not pay attention to the briefing may be their belief that accidents are not survivable.[17] Public perceptions of survivability may be substantially lower than the actual rate of 95.7 percent for all Part 121 accidents. Empowered with the knowledge of aircraft accident survivability rates, passengers may take additional steps to improve their chances of survival, including planning exit routes, paying attention to safety briefings, and reading safety cards.

[15] National Transportation Safety Board, *Emergency Evacuation of Commercial Airplanes,* Safety Study NTSB/SS-00/01. (Washington, DC: NTSB, 2000).

[16] Online posting accessed October 13, 2000 <http://www.asy.faa.gov/asy-internet/flysmart>.

[17] European Transport Safety Council, *Increasing the Survival Rate in Aircraft Accidents: Impact Protection, Fire Survivability, and Evacuation* (Brussels, Belgium: ETSC, 1996).

Findings

1. In all accidents involving Part 121 operations from 1983 through 2000, 51,207 occupants (95.7 percent) survived whereas 2,280 occupants died.

2. In 528 (93.0 percent) of the 568 accidents involving Part 121 operations from 1983 to 2000, more than 80 percent of the occupants survived.

3. In serious Part 121 accidents (those involving fire, serious injury, and either substantial aircraft damage or complete destruction), there were 2,739 occupants; 1,524 (55.6 percent) of those occupants survived.

4. In 12 (46.2 percent) of the 26 serious Part 121 accidents from 1983 through 2000, more than 80 percent of the occupants survived.

5. In serious Part 121 accidents from 1983 through 2000, there were nearly five times more impact fatalities than fire-related fatalities.

6. In serious Part 121 accidents from 1983 through 2000 that were categorized as survivable, 1,523 of the 1,988 occupants (76.6 percent) survived.

7. In serious Part 121 accidents from 1983 through 2000 that were categorized as survivable, over twice as many occupants died as a result of impact forces than as a result of fire.

8. In 12 (63.2 percent) of the 19 serious Part 121 accidents from 1983 through 2000 that were categorized as survivable, more than 80 percent of the occupants survived.

9. Public perception of survivability may be substantially lower than the actual rate of 95.7 percent for all Part 121 accidents.

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